(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 748 691 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
18.12.1996 Bulletin 1996/51

(51) Int. Cl.[6]: B41J 2/14, B41J 2/045

(21) Application number: 96201578.0

(22) Date of filing: 05.06.1996

(84) Designated Contracting States:
DE FR GB NL

(30) Priority: 12.06.1995 EP 95201536

(71) Applicant: Océ-Nederland B.V.
5914 CC Venlo (NL)

(72) Inventor: Reinten, Hans
5941 BD Velden (NL)

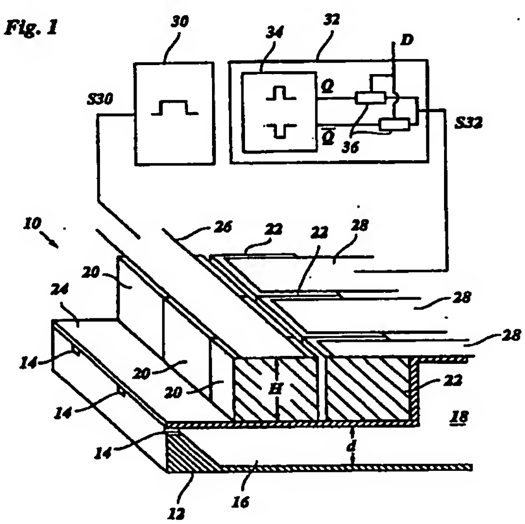
(74) Representative: Hanneman, Henri W.A.M. et al
Océ-Nederland B.V.
Patents and Information
St. Urbanusweg 43
P.O. Box 101
5900 MA Venlo (NL)

(54) Ink-jet system

(57) Ink-jet system comprising an ink channel (16) between an ink reservoir (18) and a nozzle (14), and pressurizing means (20, 22) arranged adjacent to the ink channel for generating in the ink liquid an acoustic pressure wave propagating in the ink channel, so that an ink droplet is expelled from the nozzle, wherein

- the ink channel (16) has a square cross section and a depth d which is larger than the height of the nozzle (14), such that energy losses due to reflection of the acoustic wave at the transition from the ink channel to the nozzle are minimized,
- the pressurizing means comprise a first electromechanical transducer (20) with a plate-like expansible member having a height H in the direction of the depth of the ink channel such that the ratio H/d is smaller than the ratio between the respective elastic modules of the expansible member and the ink liquid, and
- at least one second electromechanical transducer (22) is arranged at said ink channel (16) and is energized to create a pressure bias in the ink volume before the same is pressurized by the first transducer.

Fig. 1



Printed by Rank Xerox (UK) Business Services
2.13.10/3.4

Description

The invention relates to an ink-jet system comprising an ink channel between an ink reservoir and a nozzle, and pressurizing means arranged adjacent to the ink channel for generating in the ink liquid an acoustic pressure wave propagating in the ink channel, so that an ink droplet is expelled from the nozzle.

Such ink-jet systems are used as printheads in ink-jet printers.

A drop-on demand ink-jet system of the type indicated above is known for example from EP-B1-0 402 172. In this known system, the ink channel is formed in a substrate which is sandwiched between a bottom plate and a cover plate such that the top and bottom surfaces of the ink channel are formed by the cover plate and the bottom plate, respectively. The ink channel has a constant depth which is identical to the height of the nozzle, but has a larger width than the nozzle and is tapered at its front end so that its width is gradually reduced to that of the nozzle. The pressurizing means comprises a plate-like piezoelectric element which is disposed underneath the bottom plate within the area of the ink channel. The piezoelectric element is supported on a rigid support plate and has its top end face directly engaged with the bottom plate of the ink channel. When an electric voltage is applied to electrodes of the piezoelectric element, the piezoelectric material expands in vertical direction, and the elastic bottom plate is flexed inwardly of the ink channel, so that an ink droplet is expelled from the nozzle.

In a practical print head for high-speed and high-resolution printing, a plurality of ink-jet systems are integrated on a common substrate. In order to achieve objectives like large-scale integration, a high maximum frequency of drop generation and the like, the ink-jet systems should be made as compact as possible. On the other hand, the ink jet systems should be operable with moderate voltages and must nevertheless be capable of providing a sufficient energy for creating droplets of a suitable size and accelerating them to a suitable speed so that the droplets may be deposited on the recording medium with high accuracy. It is therefore desirable to optimize the efficiency, with which the mechanical energy provided by the piezoelectric element is converted into kinetic energy of the droplet.

The total energy efficiency depends largely on the following two factors: (1) the efficiency with which the mechanical energy of the piezoelectric element is converted into energy of an acoustic wave propagating in the ink liquid and (2) the efficiency with which the acoustic energy is conferred to the droplet created at the nozzle.

The first factor is determined by the ratio between the thickness of the piezoelectric element and the depth of the ink channel. Ideally, this ratio should not be much smaller than the ratio between the elastic modules of the piezoelectric material and the ink liquid. Since the piezoelectric material generally has a comparatively large elastic module and, on the other hand, the thickness of this element is limited by practical constraints, this factor requires a rather small depth of the ink channel.

The second factor depends on the ratio between the sectional areas of the nozzle and the ink channel. Ideally, this ratio should be so selected that an optimal "impedance match" is provided for the acoustic wave, in order to avoid energy losses by reflection of the acoustic wave. Since the cross-section of the nozzle is determined by the desired size of the droplets and the width of the ink channel should not be made too large, a comparatively large depth of the ink channel would be desirable in view of this factor.

Thus, when the depth of the ink channel is determined, a compromise between the two above-mentioned factors must be made, with the result that the total energy efficiency remains rather poor.

IBM Technical Disclosure Bulletin Vol. 26, No. 10B, March 1984, discloses a different type of ink-jet system in which the ink channel is defined in the interior of a tubular piezoelectric element. The outer circumferential surface of the tubular piezoelectric element is surrounded by a plurality of discrete annular conducting bands which serve as energizing electrodes, so that a plurality of piezoelectric transducers are formed which are distributed over the length of the ink channel. If the excitation of each transducer is timed properly, a pressure wave traveling towards the nozzle in the ink channel will build up its energy as it passes under each transducer.

However, an ink-jet system of this type is difficult to manufacture, and it is particularly difficult to integrate a plurality of ink-jet systems of this type into a multiple-nozzle printhead for high-speed and high-resolution printing. In addition, since the plurality of conducting bands of each piezoelectric element in each individual ink-jet system must be energized separately, a complicated control logic is required, and the wiring system needed for applying the appropriate voltages to the individual conducting bands becomes very complex when the number of nozzles in the integrated printhead is increased.

It is an object of the invention to provide an ink-jet system which has a simple structure and is nevertheless capable of providing a high energy efficiency.

According to the invention, this object is achieved in an ink-jet system according to the preamble of claim 1 wherein

the transducers are energized by nested pulses such that the transducers sequentially arranged along the ink channel are contracted one after the other in the order from the nozzle towards the ink reservoir and are then expanded one after the other in reverse order.

Because of the rectangular cross-section of the ink channel and the plate-like shape of the expansible member of the transducer, the ink-jet system is easy to manufacture and can readily be integrated in a multiple-nozzle printhead. In order to optimize the energy effi-

ciency, the depth d of the ink channel is selected in view of an optimal ratio between the cross-sectional areas of the ink channel and the nozzle, whereas the ratio H/d is allowed to deviate from the theoretical optimum. However, it can be shown that, by creating a pressure bias in the ink volume which is subject to the compression stroke of the first transducer, this theoretical optimum is shifted towards smaller values of H/d, so that a high total energy efficiency can be achieved.

The use of two or more transducers creates a synergetic effect, which means that, when the voltage to be applied to the transducers is given, the kinetic energy conferred to the droplet is larger than it would be the case if the two or more transducers were replaced by a single one with the same total dimensions. The reason is that the pressure bias created by the second transducer enhances the efficiency with which energy is transferred from the first transducer to the ink volume.

Two or more transducers are arranged along different longitudinal sections of the ink channel. In this case, the transducers have to be energized at different timings so that the first transducer will perform its compression stroke when the positive (biasing) pressure wave which has been generated by the second transducer has propagated into the section of the ink channel where the first transducer is situated. Of course, it is possible to employ three or more transducers arranged along the ink channel. Further, it is possible to provide a plurality of pairs of transducers along the ink channel such that the transducers of each pair are opposed to one another on the top and bottom sides of the ink channel and are energized sychonously.

It is not necessary that the depth of the ink channel is constant over the entire length. For example, the depth of the ink channel may be increased towards the nozzle. Then, the transducers located remote from the nozzle will have a high efficiency because they cooperate with a shallow section of the ink channel, whereas the transducers located closer to the nozzle will have a high efficiency because of the pressure bias of the ink volume in the associated sections of the ink channel, and the section of the ink channel immediately adjacent to the nozzle will have a large depth, as is required for minimizing the reflection losses at the nozzle.

According to the invention the transducers are energized by nested voltage pulses, such that, when a droplet is to be generated, the transducer which is closest to the nozzle is the first to contract and the last to expand, whereas the transducer closest to the ink reservoir is the last to contract and the first to expand. In this case, the transducers will perform their suction strokes successively, so that a negative pressure wave propagates from the nozzle towards the ink reservoir and is amplified each time it passes the transducer, the negative pressure wave being then reflected at the open end of the ink channel adjoining the ink reservoir, so that a reflected positive pressure wave propagates towards the nozzle and is successively amplified by the compression strokes of the transducers. By using this pattern for actuating the transducers, it is thus possible to exploit the reflection of the pressure wave at the open upstream end of the ink channel for amplifying the acoustic wave more efficiently.

In a drop-on-demand ink-jet system according to a preferred embodiment of the invention, at least one of the transducers is energized in response to a drop demand signal, and at least one other transducer is energized periodically, i.e. irrespective of whether or not the drop demand signal is present.

It is observed that no ink droplet will be expelled from the nozzle if the energy of the acoustic wave generated by the transducers is below a certain threshold level. Thus, when the transducer which is energized periodically is so arranged and/or controlled that the acoustic wave generated by this transducer alone is below the threshold level, an ink droplet will be generated only when the drop demand signal is present.

This embodiment has the advantage that the control logic which provides the high power output signal for periodically energizing the one transducer may be simplified significantly, because this control logic does not need to respond to the drop demand signal but is only required to provide a periodic pulse signal. In addition, in an integrated design comprising a plurality of nozzles with respectively associated ink channels and groups of transducers, the periodically energized transducers for all the nozzles may be powered by a common electrode or control line, so that the pattern of electric connections can be simplified significantly, which is particularly advantageous in case of a compact large-scale integrated device.

This particularly preferred embodiment of the invention is not limited to the case that the ink channel has a rectangular cross section. Thus, in a broader sense, the object of the invention can be achieved by an ink-jet system comprising an ink channel between an ink reservoir and a nozzle, and pressurizing means arranged adjacent to the ink channel for generating in the ink liquid an acoustic pressure wave propagating in the ink channel, so that an ink droplet is expelled from the nozzle in response to a drop demand signal, wherein said pressurizing means comprise at least two electromechanical transducers energized at different timings, and at least one of said transducers is energized periodically, irrespective of the presence or absence of the drop demand signal, whereas at least one other transducer is energized in response to the drop demand signal.

The transducer or transducers which are energized in response to the drop demand signal may be kept silent when the drop demand signal is absent. Preferably, however, the signal applied to this transducer is also derived from a periodic pulse signal, and the polarity of this pulse signal is reversed in response to the drop demand signal. Thus, the acoustic waves generated by the totality of the transducers show constructive interference in order to produce an ink droplet when the drop demand signal is present, and they show destructive

interference so that no droplet is generated, when the drop demand signal is absent. In this case, the acoustic wave which would be generated by the periodically energized transducer alone can have a comparatively large amplitude above the threshold level, so that a high level of acoustic energy can be achieved when the generation of a droplet is desired. In addition, the electronic control logic can be simplified further because the high voltage pulse signals to be applied to all transducers can be derived from periodic signals and the only effect of the drop demand signal is to change the polarity of one of these pulse signals. The timing at which the polarity is reversed in response to the drop demand signal is not critical, because the exact timings at which the transducers are actuated is determined by the pulses of the periodic signals, so that a stable drop generation can be achieved with a simple control logic.

Further details of the invention are specified in the dependent claims.

Preferred embodiments of the invention will now be described in conjunction with the accompanying drawings, in which:

Fig. 1 is a cut-away perspective view of an ink-jet system according to the invention;
Figs. 2A and 2B are pressure/displacement diagrams for a piezoelectric element and an ink volume pressurized thereby;
Fig. 3is a time chart of signals to be supplied to the piezoelectric elements of the ink-jet system shown in Figure 1; and
Figs. 4(a) - (h) illustrate the propagation and amplification of an acoustic wave in the ink channel of the system shown in Figure 1.

Figure 1 shows an ink-jet system in the form of an integrated multiple-nozzle printhead 10 which has a plurality of drop-generating units arranged on a common substrate 12. Each drop-generating unit comprises a nozzle 14, an ink channel 16 connecting the associated nozzle to a common ink reservoir 18 and two piezoelectric elements 20, 22 which are disposed along the top side of the ink channel 16 and serve as electromechanical transducers for pressurizing the ink liquid in the ink channel 16. The ink channels 16 of the individual drop generating units are formed by grooves in the top surface of the substrate 12 and are separated from one another by vertical walls (not shown). The top sides of the nozzles 14 and the ink channels 16 are defined by a flexible cover plate 24.

The main portion of the ink channel 16 disposed below the piezoelectric elements 20, 22 has a rectangular cross-section, and the front end of the ink channel is tapered toward the nozzle 14. The depth d of the ink channel 16 is larger than the height of the nozzle 14 and has been selected to provide an appropriate ratio between the cross-sectional areas of the nozzle 14 and the ink channel 16 (the width of the ink channel being limited by the pitch of the drop-genrating units).

The piezoelectric elements 20, 22 are formed by plate-like expansible members made of a piezoelectric material and provided with energizing electrodes 26, 28 at the top surface and a common ground electrode (not shown) at the bottom surface. The piezoelectric elements 22 are preferably separated from each other and each element 22 is positioned in such a way that it covers an ink channel 16.

The height H of the piezoelectric elements 20, 22 is significantly larger than the depth d of the ink channel 16. An upper limit for the height H is imposed by practical constraints. For example, it becomes more difficult to cut the piezoelectric element to the desired dimensions when the thickness thereof is increased.

When a voltage is applied for example to the electrode 28, the piezoelectric element 22 will tend to expand and will exert a pressure Pp on the flexible cover plate 24 and further on the ink volume in the ink channel 16. As a result, the cover plate 24 is caused to flex downward by a certain amount X, and the volume of the ink channel 16 is reduced accordingly.

Figure 2A is an idealized diagram which shows how the pressure Pp exerted by the piezoelectric element and the pressure Pi of the ink liquid depends on the displacement X of the cover plate 24 (the elastic force of which is neglected). The pressure Pp of the piezoelectric element starts from a comparatively high value P0 at the moment when the voltage is applied to the electrode 28 and the cover plate 24 has not yet been displaced, and then decreases linearly with the displacement x. The slope of the curve Pp is given by Ep/H, wherein Ep is the elastic module of the piezoelectric material. On the other hand, the pressure Pi of the ink liquid is initially zero and increases linearly with the displacement X, the slope being given by Ei/d, wherein Ei is the elastic module of the ink liquid. The displacement of the cover plate 24 will reach a value Xe at which there exists equilibrium between the pressures Pp and Pi. The mechanical work per unit area conferred to the ink liquid is represented by the hatched area W in Figure 2A.

Figure 2B illustrates a situation in which the ink liquid has already a certain initial pressure or bias pressure Pb. Accordingly, the curve Pi' representing the pressure of the ink liquid is shifted by the amount Pb. It is readily seen that the work W' conferred to the ink liquid (hatched area in Figure 2B) is significantly larger than in the case illustrated in Figure 2A.

The ink-jet system illustrated in Figure 1 takes advantage of this effect in the following manner.

One piezoelectric element is used for creating the initial bias pressure Pb in the section of the ink channel 16 underneath the other piezoelectric element. Then, the electrode of the other piezoelectric element is energized in order to confer a higher amount of energy (corresponding to the work W') to the ink liquid. The mechanical energy of the piezoelectric elements is thus transformed into acoustic energy with high efficiency. When the wave front of the high pressure wave propagating in the ink channel 16 reaches the nozzle 14, this

energy is efficiently transformed into kinetic energy of the ink droplet, because the cross section of the ink channel 16 is so dimensioned that energy losses due to reflection of the acoustic wave at the nozzle 14 are minimized.

As is shown in Figure 1, the electrode 26 which is common to the piezoelectric elements 20 of all drop generating units, is connected to a drive circuit 30, and each of the electrodes 28 is connected to another drive circuit 32 which receives a drop demand signal D.

Figure 3 is a time chart illustrating exemplary wave forms of the drop demand signal D and the output signals S30 and S32 of the drive circuits 30 and 32. The drive circuit 30 outputs a periodic pulse signal with a fixed period T and a certain pulse width PW1, irrespective of whether or not the drop demand signal D is present. The drive circuit 32 generates a pulse signal which has the same period T. The centers of the pulses of this pulse signal are identical with the centers of the pulses of the signal S30, but the pulse width PW2 of the signal S32 is only one third of the pulse width PW1. When the drop demand signal D is present, then the pulse of the signal S32 has the same polarity as the pulses of the signal S30, and when the drop demand signal D is absent, the pulses of the signal S32 have the opposite polarity.

The operation of the ink-jet system according to Figure 1 will now be explained in detail with reference to Figures 3 and 4. Figure 4 symbolizes the propagation of an acoustic pressure wave in the ink channel 16 relative to the piezoelectric elements 20, 22 for each of the time points t0 - t7 indicated in Figure 3.

At the time t0, the signal S30, i.e. the voltage applied to the electrode 26 changes such that the piezoelectric elements 20 are contracted. As a result, a negative pressure wave is generated below the piezoelectric element 20, as is shown in Figure 4(a). This negative pressure wave will spread in both directions.

At the time t1, the right wave front of the negative pressure wave has reached the right end of the piezoelectric element 22, i.e. the end adjacent to the ink reservoir 18. At this instant, the signal S32, i.e. the voltage applied to the electrode 28 of the drop generating system for which the drop demand signal D is present, is also changed so that this piezoelectric element 22 is also contracted. As a result, the negative pressure wave below the piezoelectric element 22 is amplified (Figure 4(b)).

Almost at the same instant the right wave front reaches the upstream end of the ink channel 16 adjoining the ink reservoir 18. At this open end, the negative pressure wave is reflected with a phase shift of 180, so that the reflected wave has a positive pressure.

When the wave front of this positive pressure wave reaches again the borderline between the piezoelectric elements 20 and 22, at the time t2, the signal S32 drops to zero. As a result, the piezoelectric element 22 expands, and the high pressure wave is amplified again as is shown in Figure 4(c).

At the time t3, the positive pressure wave has travelled into the section of the ink channel 16 below the piezoelectric element 20. At this instant, the signal S30 drops to zero, and the piezoelectric element 20 expands so that the positive pressure wave is amplified once more. Thus, an acoustic wave carrying a high amount of energy will propagate towards the nozzle 14 and will cause the creation of the desired ink droplet.

The operation of the piezoelectric elements in absence of the drop demand signal D is illustrated in Figures 4(e) - (h).

At the time t4, the piezoelectric element 20 is energized in the same manner as described above. Figure 4(e) is therefore equivalent to Figure 4(a).

At the time t5, the signal S32 assumes a negative value, so that the associated piezoelectric element 22 will expand. As a result, the negative pressure wave generated at the time t4 is substantially cancelled by destructive interference (Figure 4(f)).

At the time t6, the signal S32 raises again to zero so that the piezoelectric element 22 is contracted to its rest position. As a result, a negative pressure wave will propagate towards the piezoelectric element 20, as is shown in Figure 4(g).

At the time t7, the signal S34 drops to zero and the piezoelectric element 20 expands, so that the negative pressure wave is cancelled by destructive interference. Thus, no substantial pressure will be observed at the nozzle 14.

Since the system of ink in the nozzle and in particular the meniscus of the ink liquid in the nozzle 14 has a certain stability, it is not necessary that the acoustic wave is cancelled completely when the drop demand signal is absent. It is sufficient that the amplitude of the acoustic wave is reduced to such an extent that no droplet will be generated.

It may therefore be advantageous to modify the arrangement in such a manner that the piezoelectric element 20 provides more power than the element 22. This can be achieved by increasing the output voltage of the drive circuit 30 in comparison to the of the drive circuit 32. Since the drive circuit 32 must respond to the drop demand signal D, it will be appreciated that it is advantageous if this drive circuit can be operated at a lower voltage.

The embodiment which has been described above may be modified in various ways. For example, the piezoelectric elements 20 and 22 may have different lengths. For the reasons indicated above, it will be preferable to provide a larger length for the piezoelectric element 20. Of course, the timings of the signals S30 and S32 must be adapted to the respective lengths of the piezoelectric elements.

While, in the embodiment described above, the signal S32 is a tri-state signal, a bi-state signal may also be employed, as is indicated by the dot-dashed line in Figure 3. This modified waveform of the signal S32 may be derived from a periodic pulse signal by inverting the

polarity of this periodic pulse signal in accordance with the drop demand signal D. In this case, the piezoelectric element 22 will perform additional retraction and expansion strokes, for example at the time td in Figure 3. These additional strokes however are not strong enough to create an ink droplet, so that they have no adverse effect on the performance of the system.

The drive circuit 32 may for example be implemented by a pulse generator 34 which provides a periodic pulse signal Q and by electronic switches 36 which connect the electrode 28 alternatingly to the output Q and to the inverted output Q of this pulse generator in response to the drop demand signal D. In this case, the power devices for energizing all piezoelectric elements may be formed by simple pulse generators which operate with a fixed frequency and pulsewidth, and the drop demand signal D is only applied to the electronic switches 36. These switches may be comparatively slow, because the inversion of the signal S32 may occur at any time between t3 and t4.

If the power of the piezoelectric element 20 is made small enough, so that this element alone is not capable of generating an ink droplet, then it is also possible to suppress the pulses of the signal S32 completely when the drop demand signal D is absent.

Other possible modifications of the described embodiment will readily occur to a person skilled in the art. For example, the function principle described above may easily by extended to arrangements with three or more piezoelectric elements for each ink channel. It is also possible to alter the positions of the transducer 20 which is energized periodically and the transducer 22 which is energized in response to the drop demand signal in such a way that latter transducer 22 is closer to the nozzle than the other transducer 20. In this case it is clear that energization should be changed accordingly.

It should therefore be noted that the invention is not limited to the embodiments explicitly described herein but encompasses all modifications which fall within the scope of the appended claims.

Claims

1. Ink-jet system comprising an ink channel (16) between an ink reservoir (18) and a nozzle (14), and pressurizing means (20, 22) arranged adjacent to the ink channel for generating in the ink liquid an acoustic pressure wave propagating in the ink channel, so that an ink droplet is expelled from the nozzle, wherein

    - the ink channel (16) has a substantially rectangular cross section and a depth d which is larger than the height of the nozzle (14), such that energy losses due to reflection of the acoustic wave at the transition from the ink channel to the nozzle are minimized,
    - the pressurizing means comprise a first electromechanical transducer (20) with a plate-like expansible member having a height H in the direction of the depth of the ink channel such that the ratio H/d is smaller than the ratio (Ep/Ei) between the respective elastic modules (Ep, Ei) of the expansible member and the ink liquid, and
    - at least one second electromechanical transducer (22) is arranged at said ink channel (16) and is energized to create a pressure bias (Pb) in the ink volume before the same is pressurized by the first transducer

    wherein both transducers (20, 22) are energized by pulse-like voltage signals (S30, S32), such that each transducer is first contracted and then expanded, characterized in that the transducers (20, 22) are energized by nested pulses such that the transducers (20, 22) sequentially arranged along the ink channel (16) are contracted one after the other in the order from the nozzle (14) towards the ink reservoir (18) and are then expanded one after the other in reverse order.

2. Ink-jet system according to any of the preceding claims, wherein at least one (22) of the transducers is energized in response to a drop demand signal (D) whereas at least one other transducer (20) is energized periodically, irrespective of the presence or absence of the drop demand signal.

3. Ink-jet system according to claim 2, wherein the transducer (20) which is energized periodically is the one which is located closest to the nozzle (14).

4. Ink-jet system according to claim 2 or 3, wherein the transducer (22) which is energized in response to the drop demand signal (D) receives a pulse signal (S32) with such a timing and/or polarity in relation to the timing and/or polarity of the periodic signal (S30) applied to the other transducer (20) that the acoustic waves generated by each of the transducers (20, 22) show constructive interference when the drop demand signal is present and show destructive interference when the drop demand signal is absent.

5. Ink-jet system according to claim 4, wherein the signal (S32) applied to the transducer (22) in response to the drop demand signal is a tri-state signal which includes either positive or negative pulses in relation to a zero-potential, depending on the state of the drop demand signal (D).

6. Ink-jet system according to claim 4 or 5, wherein a drive circuit (32) for energizing the transducer (22) in response to the drop demand signal (D) comprises a pulse generator (34) for generating a periodic pulse signal (Q) and means (36) for inverting this pulse signal dependent on the presence or

absence of the drop demand signal.

Fig. 1

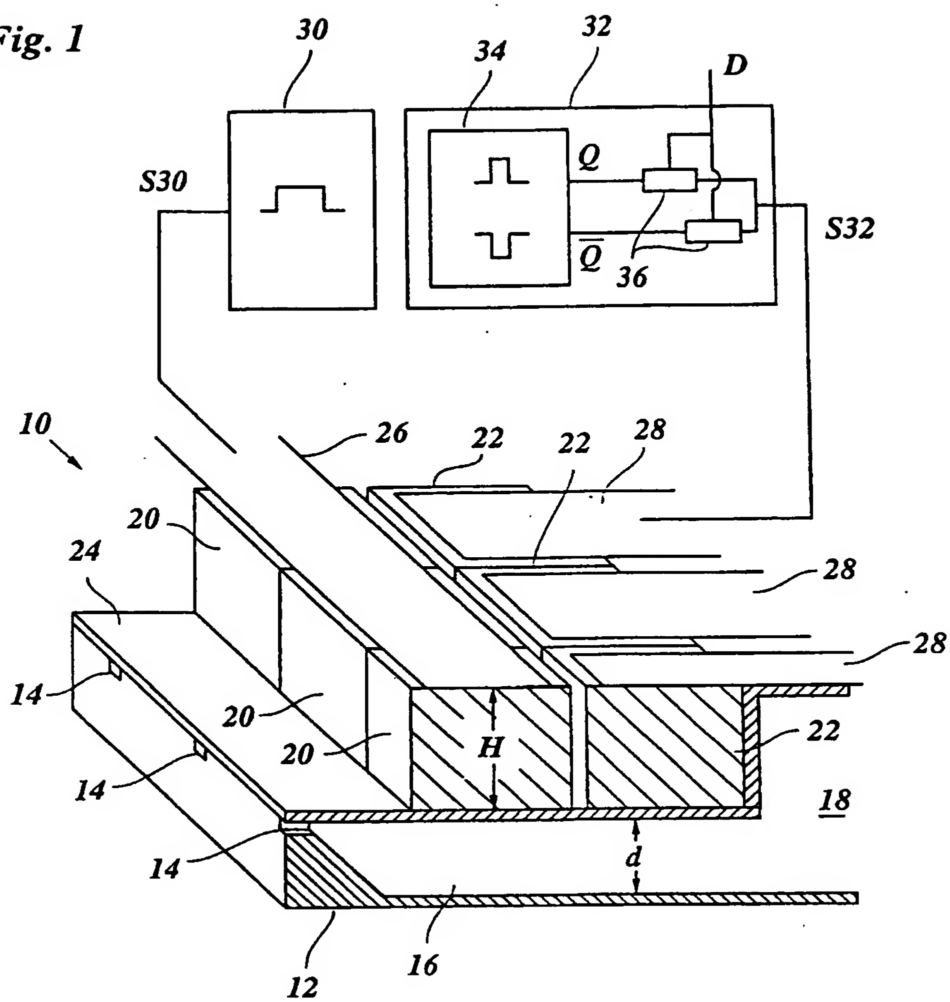


Fig. 2A

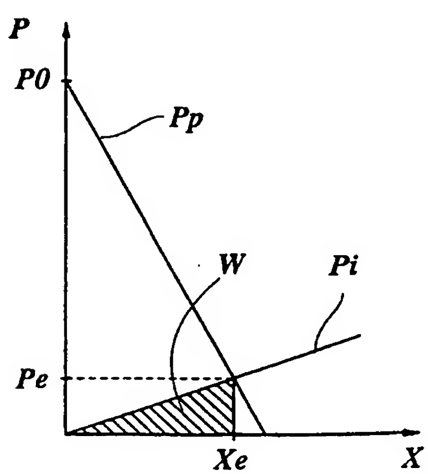


Fig. 2B

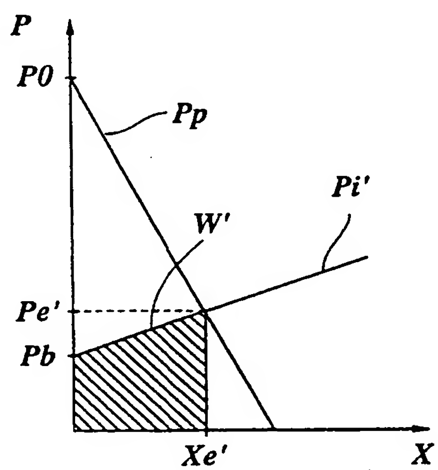


Fig. 3

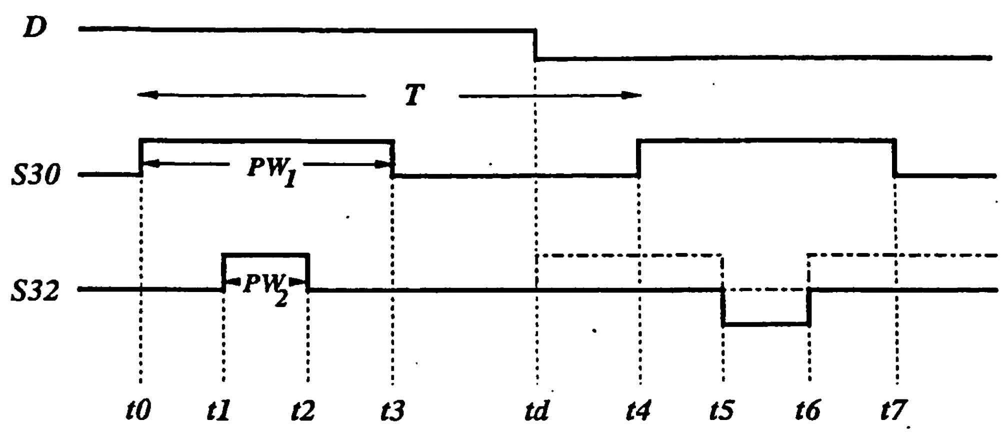
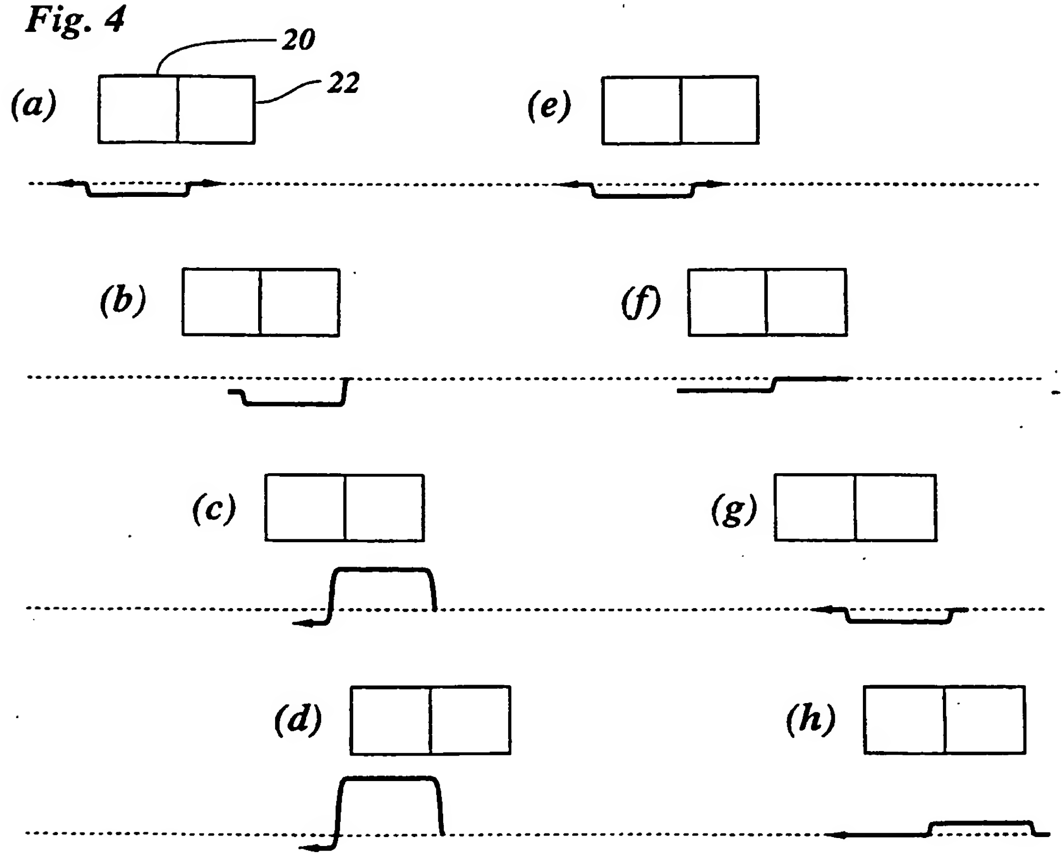


Fig. 4



(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 748 691 A3

(12) EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
30.07.1997 Bulletin 1997/31

(43) Date of publication A2:
18.12.1996 Bulletin 1996/51

(21) Application number: **96201578.0**

(22) Date of filing: **05.06.1996**

(51) Int. Cl.^{6}: **B41J 2/045**

(84) Designated Contracting States:
DE FR GB NL

(30) Priority: **12.06.1995 EP 95201536**

(71) Applicant: **Océ-Nederland B.V.**
5914 CC Venlo (NL)

(72) Inventor: **Reinten, Hans**
5941 BD Velden (NL)

(74) Representative: **Hanneman, Henri W., Dr. et al**
Océ-Technologies B.V.
Patents & Information
St. Urbanusweg 43
P.O. Box 101
5900 MA Venlo (NL)

(54) Ink-jet system

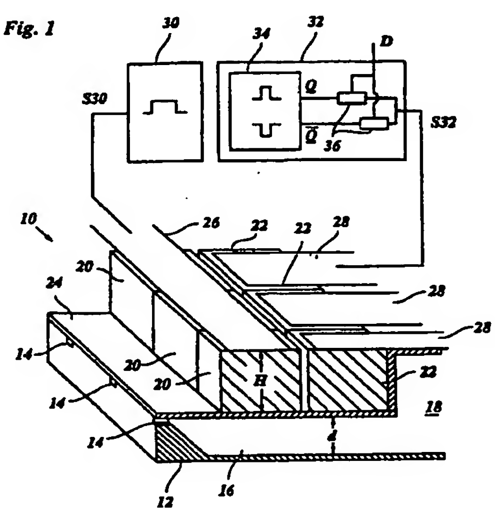
(57) Ink-jet system comprising an ink channel (16) between an ink reservoir (18) and a nozzle (14), and pressurizing means (20, 22) arranged adjacent to the ink channel for generating in the ink liquid an acoustic pressure wave propagating in the ink channel, so that an ink droplet is expelled from the nozzle, wherein

- the ink channel (16) has a square cross section and a depth d which is larger than the height of the nozzle (14), such that energy losses due to reflection of the acoustic wave at the transition from the ink channel to the nozzle are minimized,

- the pressurizing means comprise a first electromechanical transducer (20) with a plate-like expansible member having a height H in the direction of the depth of the ink channel such that the ratio H/d is smaller than the ratio between the respective elastic modules of the expansible member and the ink liquid, and

- at least one second electromechanical transducer (22) is arranged at said ink channel (16) and is energized to create a pressure bias in the ink volume before the same is pressurized by the first transducer.

Fig. 1



EP 0 748 691 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 20 1578

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	DE 43 28 433 A (HEIDELBERGER DRUCKMASCHINEN AG) * the whole document *	1-6	B41J2/045
A	PATENT ABSTRACTS OF JAPAN vol. 009, no. 128 (M-384), 4 June 1985 & JP 60 011369 A (FUJITSU KK), 21 January 1985, * abstract *	1	
A	US 4 525 728 A (KOTO) * the whole document *	1-6	
T	"1985 Sid International Symposium, Digest of Technical Papers" , PALISADES INSTITUTE FOR RESEARCH SERVICES, INC. , NEW YORK XP002031532 * page 317 - page 320 *	1-6	
A	US 4 364 069 A (KOBAYASHI) * the whole document *	1-6	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	EP 0 214 855 A (NEC CORPORATION) * the whole document *	1-6	B41J
A	US 4 672 398 A (KUWABARA ET AL.) * the whole document *	1-6	
A	EP 0 072 685 A (DENNE) * the whole document *	1-6	
A	EP 0 608 135 A (SHARP) * the whole document *	1-6	
A	GB 2 104 006 A (SHINSHU SKI KK) * the whole document *	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26 May 1997	Meulemans, J-P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document